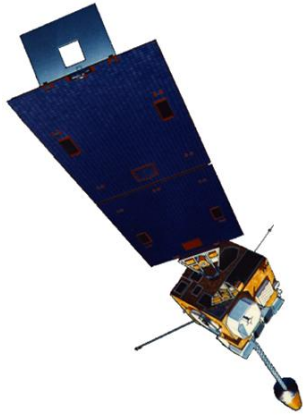
National Environmental Satellite, Data, and Information Service



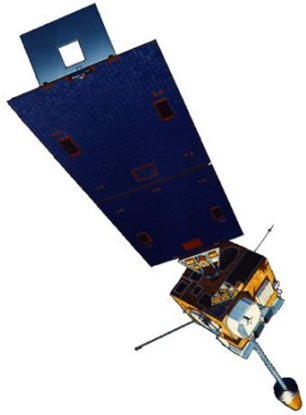
NOAA Satellite Calibration/Validation Programs

Changyong Cao, Ph.D.
Research Physical Scientist

NOAA/NESDIS/Center for Satellite Applications and Research

Presented at JACIE, March 2011, Boulder, CO

National Environmental Satellite, Data, and Information Service

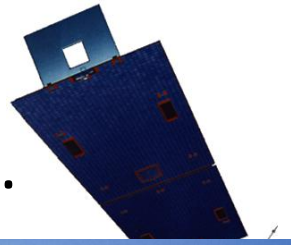


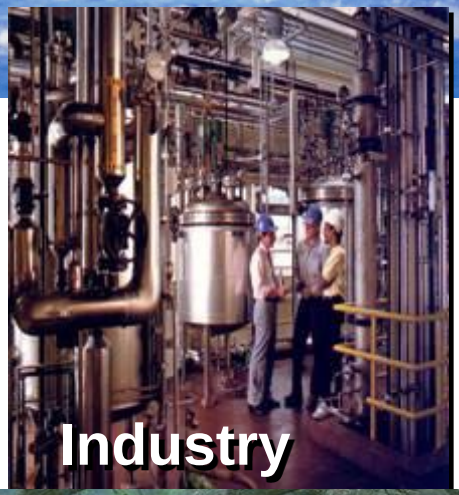
Outline

- NOAA polar-orbiting & geostationary satellite programs
- GOES-R cal/val
- NPOESS to JPSS transition
- Re-calibration to generate climate data records
- WMO/Global Space-based Inter-calibration System (GSICS)

National Environmental Satellite, Data, and Information Service

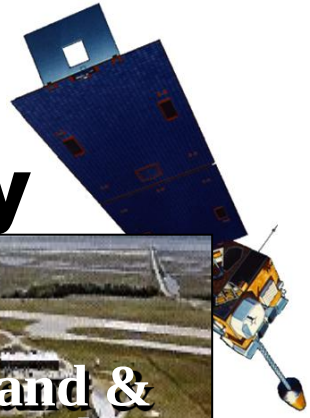
NOAA Data and Information are Essential for…

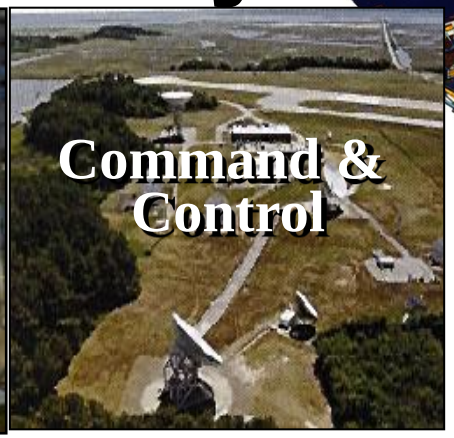


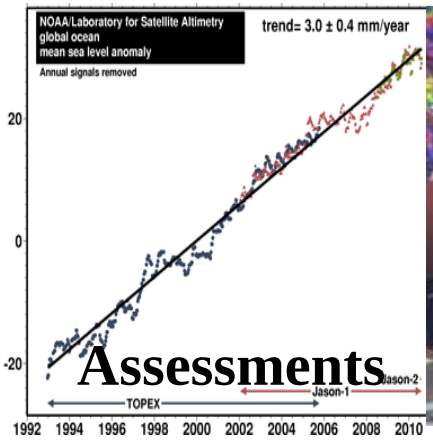


National Environmental Satellite, Data, and Information Service

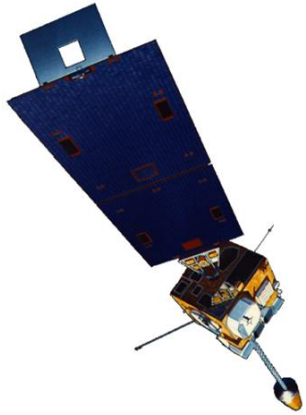
An End-to-End Responsibility







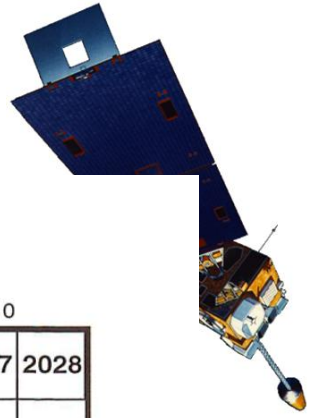
National Environmental Satellite, Data, and Information Service



NOAA Satellite Programs

- Operational Programs
  - 30+ years of NOAA satellites
    - AVHRR/HIRS/AMSU
    - NOAA-19 launched in 2009 – the last in the NOAA satellite series
  - MetOp-A (launched in 2006); MetOp-B to be launched in 2012
  - Jason 2 transitioned to NOAA; Jason 3 to be launched in 2013
- Satellite Acquisition Programs
  - GOES-R: ABI/GLM/SWX
  - JPSS (formerly known as NPOESS)
    - VIIRS/CrIS/ATMS/OMPS
- Climate Program
  - Historical NOAA satellite instruments

National Environmental Satellite, Data, and Information Service



Continuity of GOES Operational Satellite Program

Calendar Year

As of July 26, 2010

2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028

GOES-11 *GOES West*

GOES-12 *Back up and South American coverage*

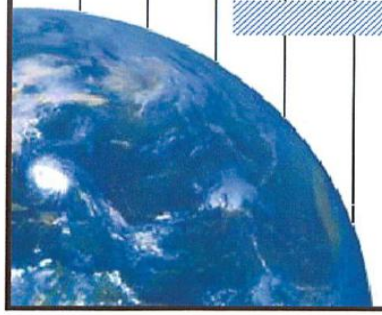
GOES-13 *GOES East*

GOES-14 *On-orbit spare*

GOES-15 *In post launch checkout*

GOES-R

GOES-S



Approved:

Deputy Assistant Administrator
for Systems

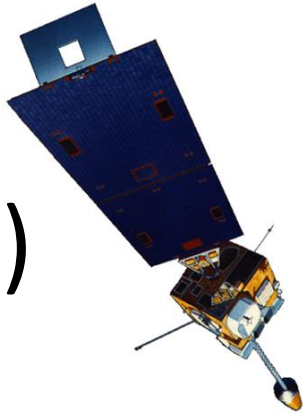
Satellite is operational beyond design life

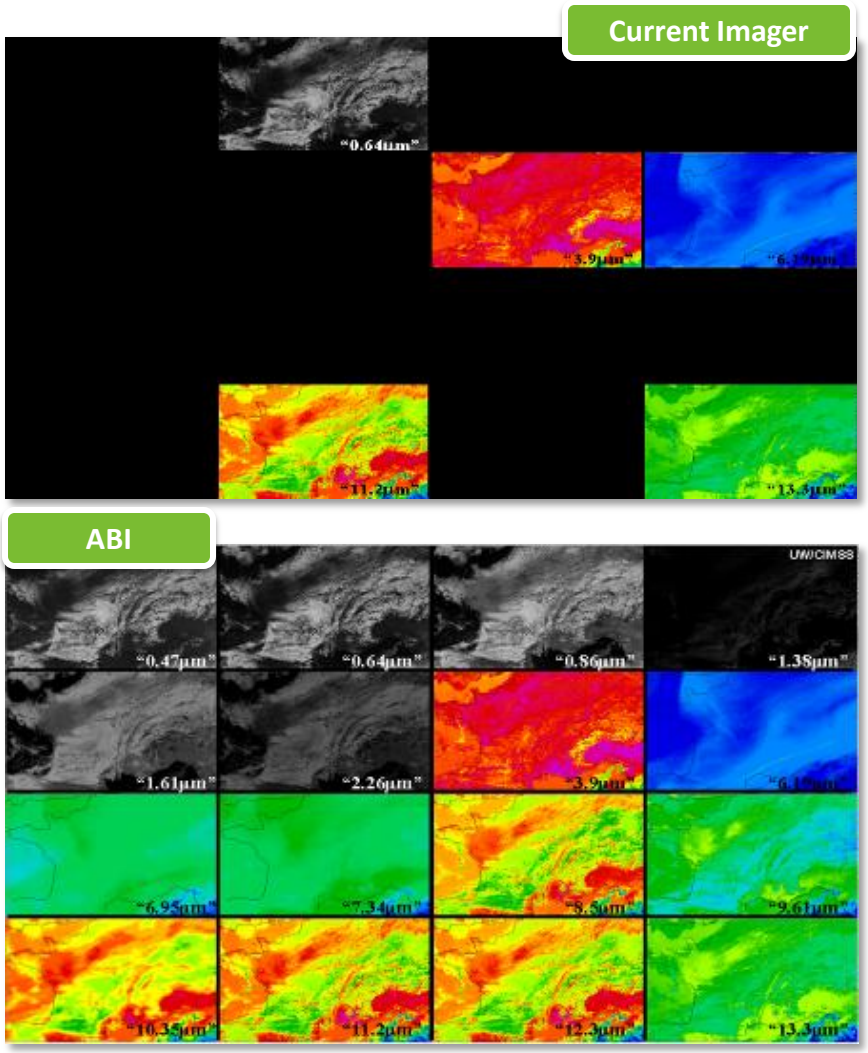
On-orbit GOES storage

Operational

National Environmental Satellite, Data, and Information Service

GOES-R
Advanced Baseline Imager (ABI)





ABI is the next generation GOES Imager

GOES-R is scheduled to launch in 2015

	Current	ABI
Spectral Coverage	5 Bands	16 Bands
Spatial Resolution		
0.64µm visible	1.0 km	0.5 km
Other visible/near-IR	N/A	1.0 km
Bands > 2µm	4 km	2 km
Spatial Coverage		
Full disk	Scheduled (3 hrly)	4 per hour
Visible (Reflective)		
On-orbit calibration	No	Yes

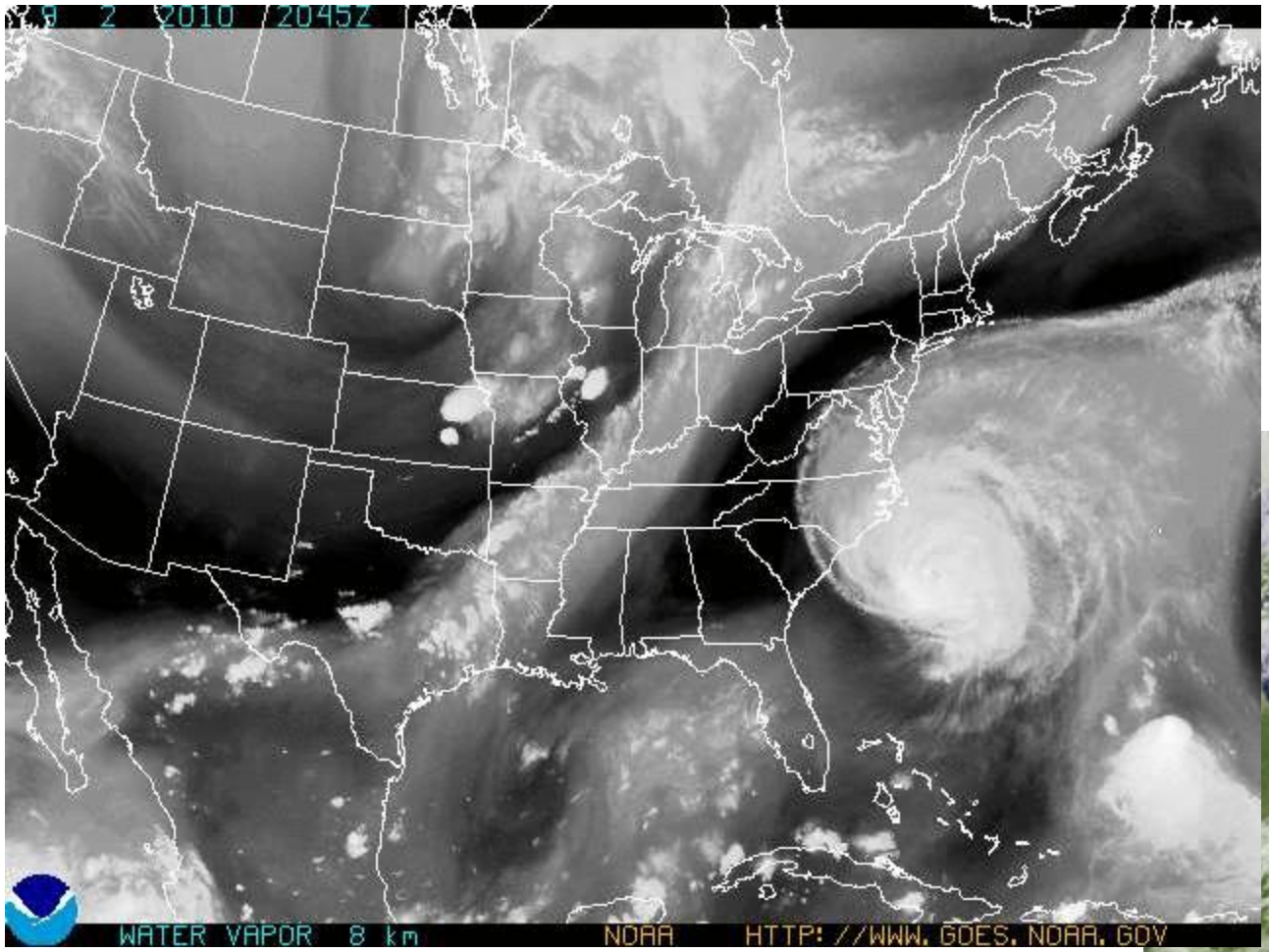
- **Increase in spectral coverage facilitates more quantitative products**
- **Need for more rigorous calibration/validation**

http://cimss.ssec.wisc.edu/goes/abi/

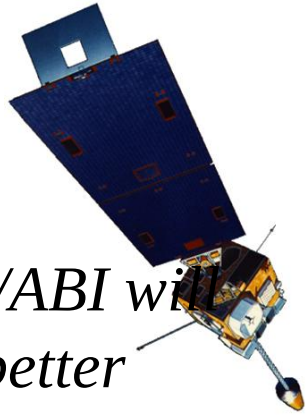
National Environmental Satellite, Data, and Information Service

GOES(East) Water Vapor Observations

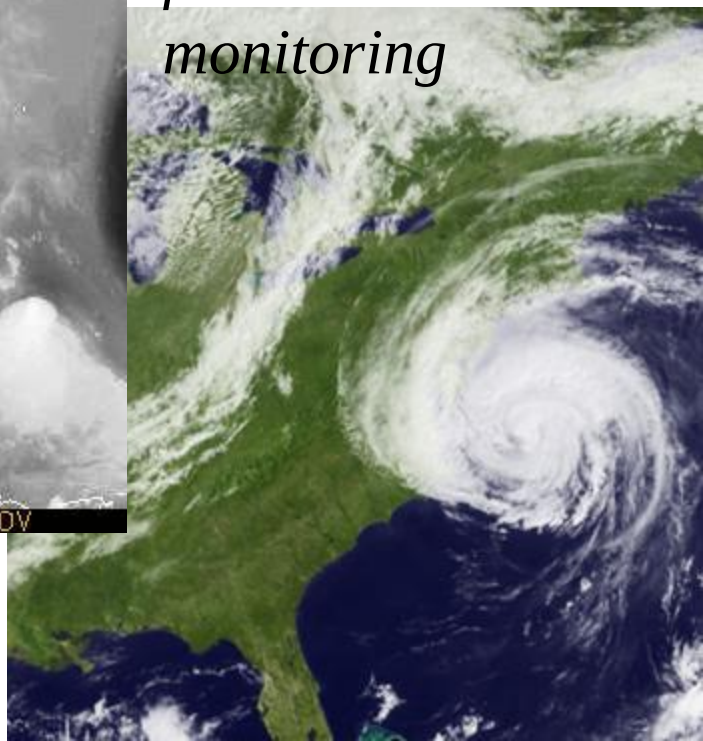
- The need for 24-7 remote sensing data



Hurricane Earl

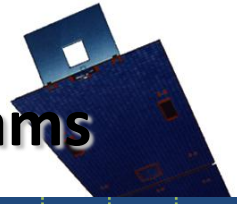


GOES-R/ABI will provide better temporal, spectral, spatial, and radiometric resolution for Hurricane monitoring



National Environmental Satellite, Data, and Information Service

Continuity of Polar Operational Satellite Programs



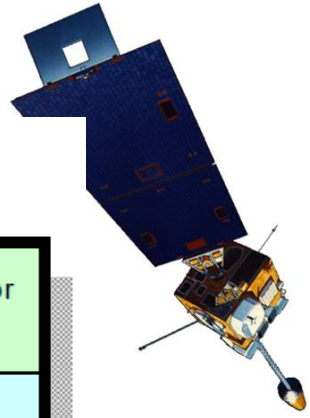
	CY 09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
AM Orbit	DMSP 17																										
					DMSP 19																						
													DWSS 1														
													TBD		DWSS 2												
Mid Morning Orbit	DMSP F16																										
		DMSP 18																									
		MetOp-A					DMSP 20																				
					MetOp-B																						
											MetOp-C																
		TERRA															EPS-SG										
PM Orbit									GCOM-W1 thru W3**																		
		NOAA-19					*Climate and User Services																				
				NPP																							
					*Launch Ready					JPSS 1																	
		AQUA									*Launch Ready				JPSS 2												

LEGEND

DMSP: Defense Meteorological Satellite Program
DWSS: Defense Weather Satellite System
MetOp: Meteorological Operational satellite for EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites)
EPS-SG: EUMETSAT Polar System – Second Generation
Terra & Aqua: NASA'S Earth Observing Satellites
NOAA-19: NOAA's Polar-orbiting Operational Satellite
NPP: NPOESS Preparatory Project
JPSS: Joint Polar Satellite System
*Details to be defined during the transition period
**Negotiations ongoing with JAXA

National Environmental Satellite, Data, and Information Service

VIIRS Sensor Bands



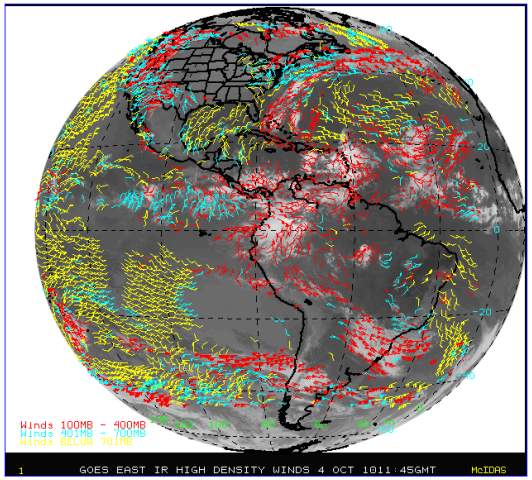
		Band No.	Wave-length (μm)	Horiz Sample Interval (km Downtrack x Crosstrack)		Driving EDRs	Radi-ance Range	Ltyp or Ttyp
				Nadir	End of Scan			
VIS/NIR FPA	Silicon PIN Diodes	M1	0.412	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	44.9 155
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	40 146
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	32 123
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	21 90
		I1	0.640	0.371 x 0.387	0.80 x 0.789	Imagery	Single	22
		M5	0.672	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	10 68
		M6	0.746	0.742 x 0.776	1.60 x 1.58	Atmospheric Corr'n	Single	9.6
		I2	0.865	0.371 x 0.387	0.80 x 0.789	NDVI	Single	25
		M7	0.865	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	6.4 33.4
CCD		DNB	0.7	0.742 x 0.742	0.742 x 0.742	Imagery	Var.	6.70E-05
S/MWIR	PV HgCdTe (HCT)	M8	1.24	0.742 x 0.776	1.60 x 1.58	Cloud Particle Size	Single	5.4
		M9	1.378	0.742 x 0.776	1.60 x 1.58	Cirrus/Cloud Cover	Single	6
		I3	1.61	0.371 x 0.387	0.80 x 0.789	Binary Snow Map	Single	7.3
		M10	1.61	0.742 x 0.776	1.60 x 1.58	Snow Fraction	Single	7.3
		M11	2.25	0.742 x 0.776	1.60 x 1.58	Clouds	Single	0.12
		I4	3.74	0.371 x 0.387	0.80 x 0.789	Imagery Clouds	Single	270 K
		M12	3.70	0.742 x 0.776	1.60 x 1.58	SST	Single	270 K
		M13	4.05	0.742 x 0.259	1.60 x 1.58	SST Fires	Low High	300 K 380 K
LWIR	PV HCT	M14	8.55	0.742 x 0.776	1.60 x 1.58	Cloud Top Properties	Single	270 K
		M15	10.763	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K
		I5	11.450	0.371 x 0.387	0.80 x 0.789	Cloud Imagery	Single	210 K
		M16	12.013	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K

Rev. 062708

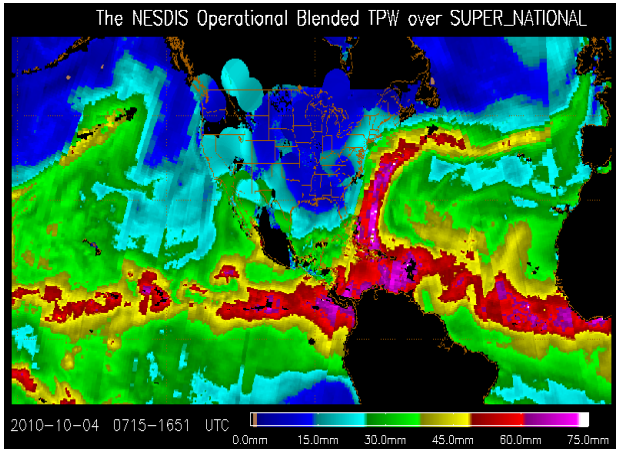
National Environmental Satellite, Data, and Information Service

Atmospheric Products: Examples

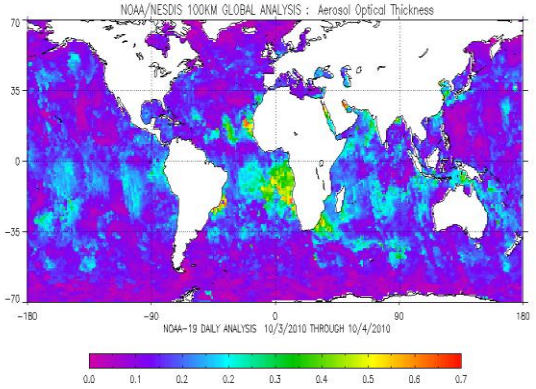
Winds



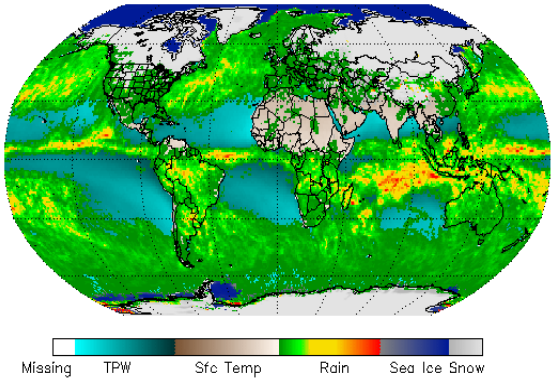
Total Precipitable Water



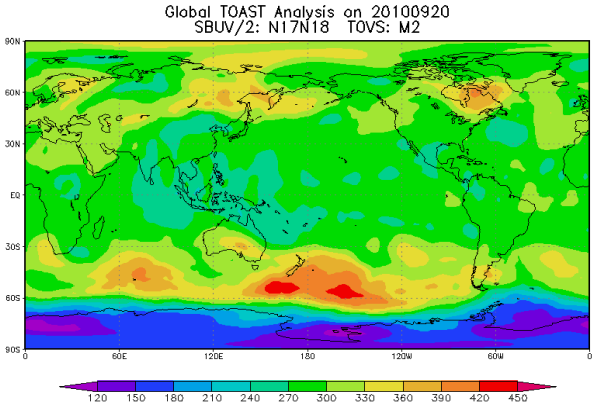
Aerosol Optical Thickness



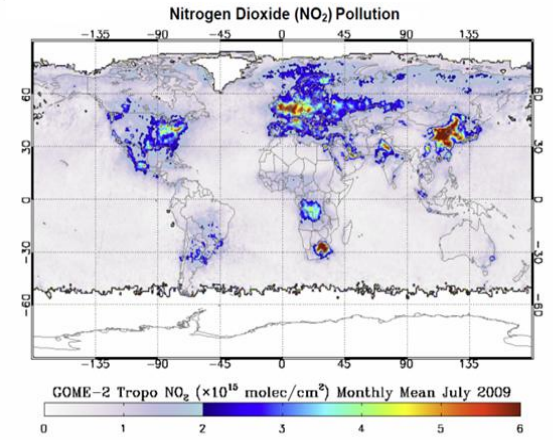
Precipitation



Ozone

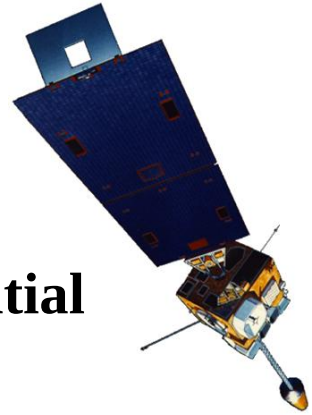


Trace Gases

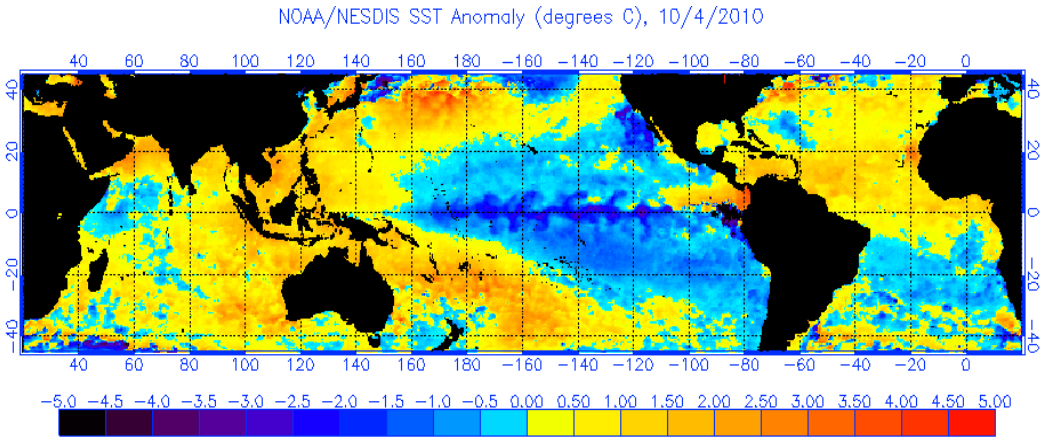


National Environmental Satellite, Data, and Information Service

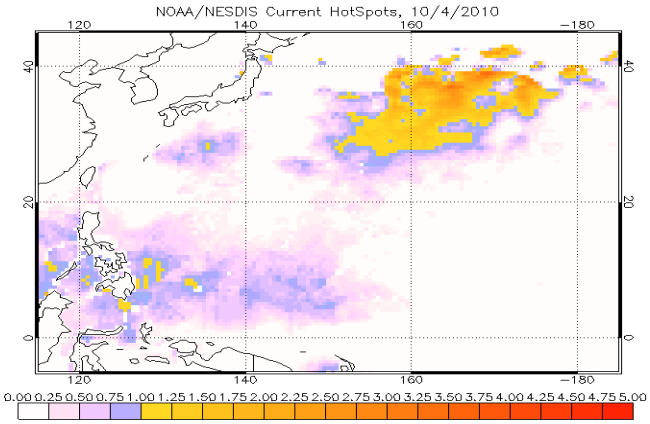
Ocean Products: Examples

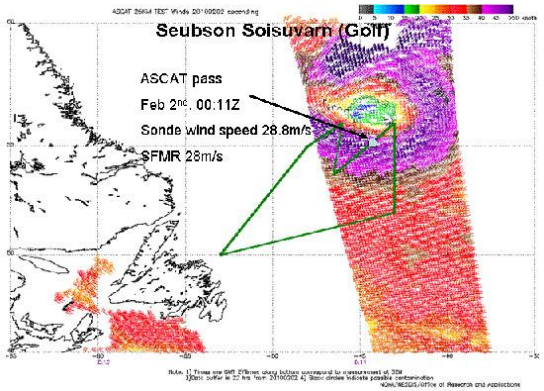


SST Anomalies

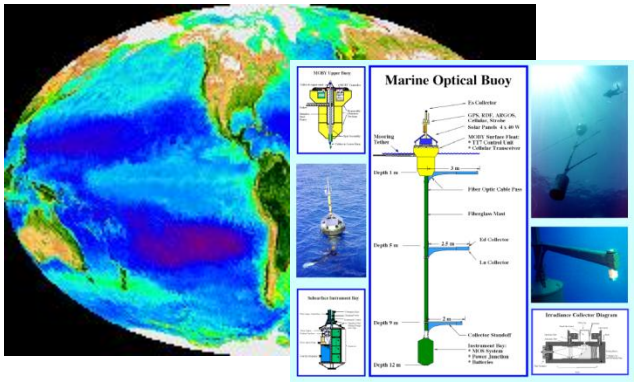


Hot Spots: Potential Coral Bleaching

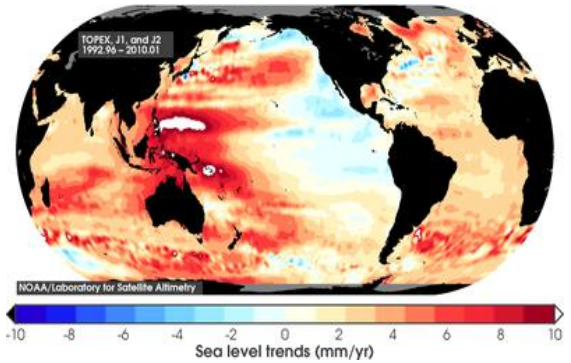




ASCAT Winds



MOBY & Ocean Color

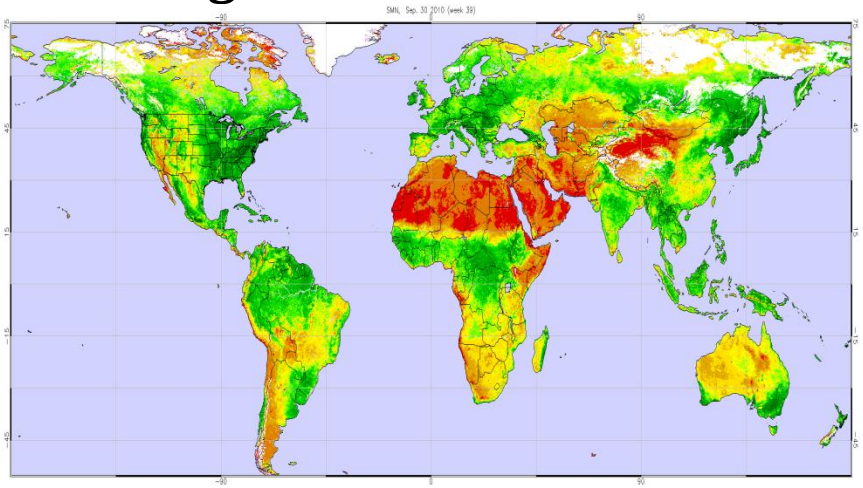


Sea Level Trend

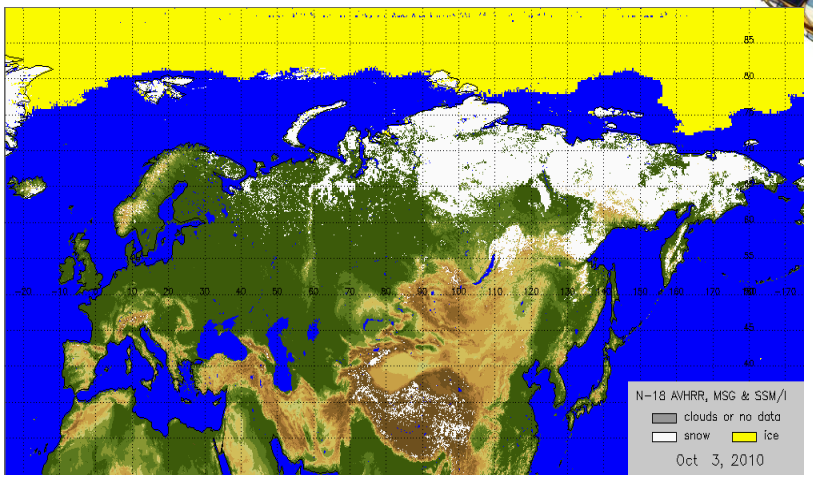
National Environmental Satellite, Data, and Information Service

Land Surface Products: Examples

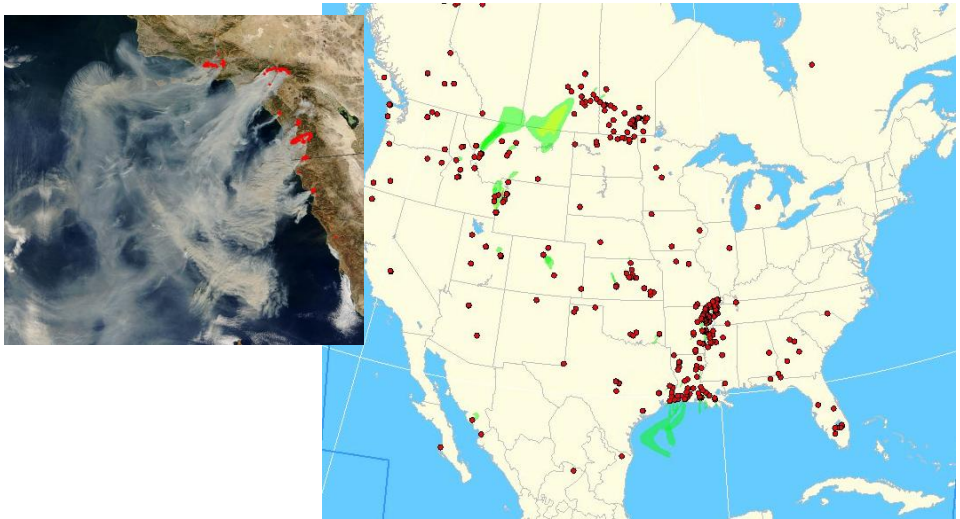
Vegetation Health



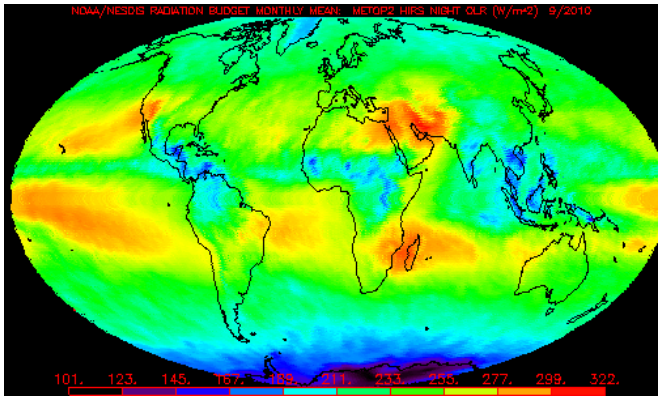
Snow and Ice



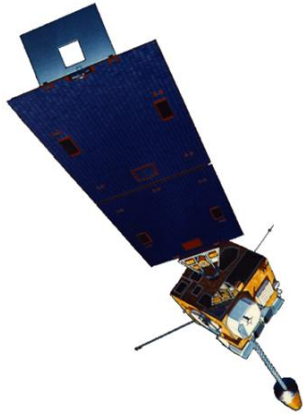
Fires and Smoke



Outgoing Longwave Radiation

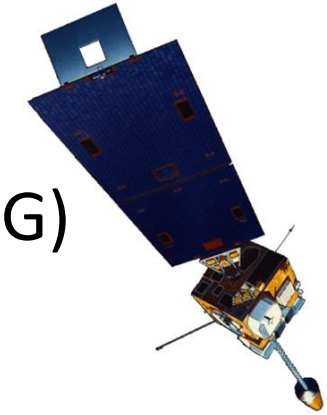


National Environmental Satellite, Data, and Information Service



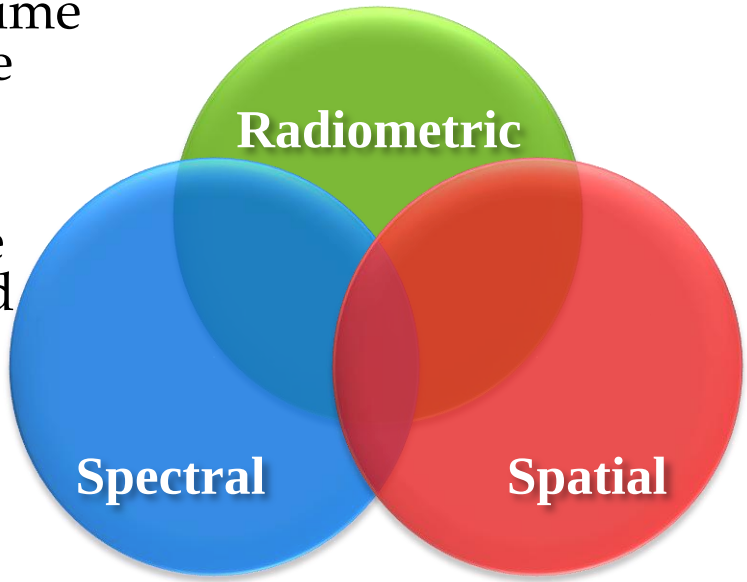
NOAA Satellite Instrument Cal/Val

GOES-R Calibration/Validation Working Group (CWG)



- Verify and ensure well-calibrated, & well-navigated GOES-R L1b data for the life time of the instruments (ABI, GLM, and Space Weather)

- Ensure Level 1B data quality and science integrity. Provide technical oversight and IV&V for:
  - Radiometric calibration
  - Spectral calibration
  - Spatial calibration/navigation check
  - Independent verification of L1B data

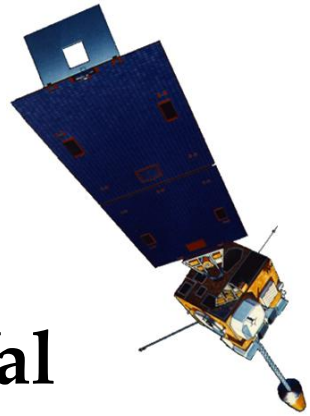


- Evaluate and mitigate instrument performance risks (e.g., possible striping, straylight, noise, cross-talk, RVS, spectral response uncertainty, etc)

- Provide technical support to the Flight and Ground through PSE

National Environmental Satellite, Data, and Information Service

GOES-R Life Cycle Cal/Val Support



CWG Members

NESDIS/STAR

Ground Segment V&V Team

Prelaunch V&V Team

Post Launch & Operational team

Flight Project (NASA GSFC)

Ground Project (Harris Co.)

NIST

Optical Technology Division

Electron & Optical Physics Division

SWPC (Space Weather Prediction Center)

Marshal Space Flight Center

MIT Lincoln Laboratory

Four Phases of Cal/Val

1 Pre-Launch

Working closely with the flight project, NASA, NIST, and the vendor to verify instrument performance on the ground.
Support the development of ground processing systems

2. Operational check-out

Verify instrument performance meet specification

3. On-orbit verification
Characterize on-orbit instrument performance to ensure meet science needs

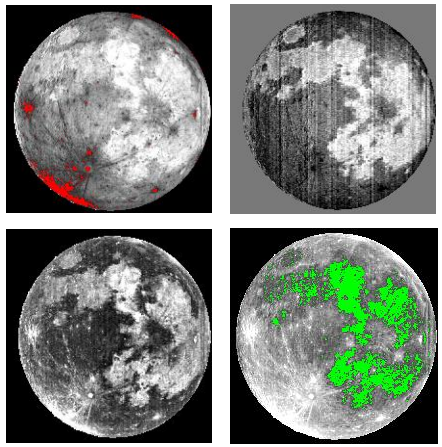
4. Long-Term Monitoring
Degradation trending, anomaly resolution, recalibration to support climate studies

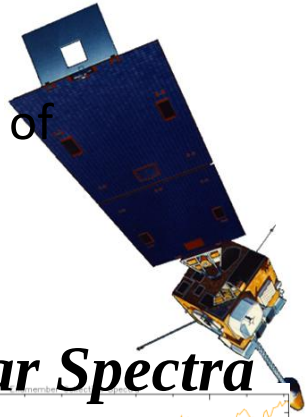
National Environmental Satellite, Data, and Information Service

Hyperspectral Characterization of the Lunar Surface in Support of GOES-R Cal/Val

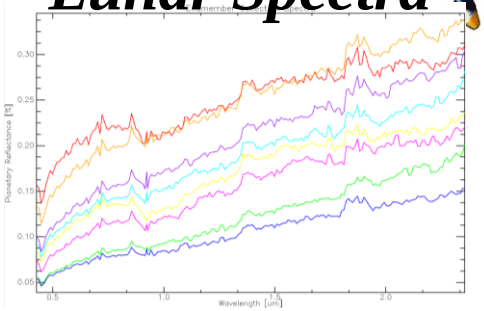
GOES-R Advance Baseline Imager
- **Increase in spectral coverage facilitates more quantitative products**
- **Increased emphasis on calibration**
- **GOES-R has an onboard solar diffuser**
- **Need solar diffuser verification due to expected on-orbit degradation**

Characterization



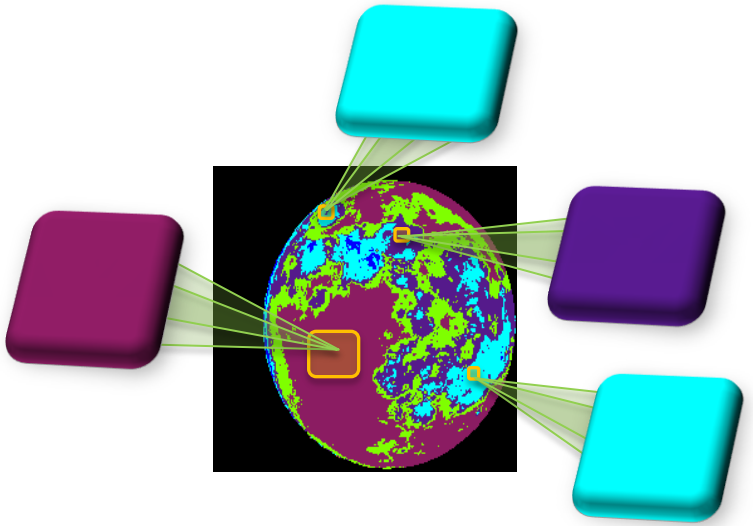


Lunar Spectra



- Performed a hyperspectral characterization of the lunar surface using a Hyperion image (CEOS WGCV Working Group on Calibration/Validation)

Characterization Identified:
- 5-6 unique spectral classes
- spatial coverage of each class
- potential spatially, spectrally, and temporally invariant lunar calibration sites
- Band ratio comparisons of the entire moon to each candidate site demonstrated reduced variability



Sponsored by GOES-R

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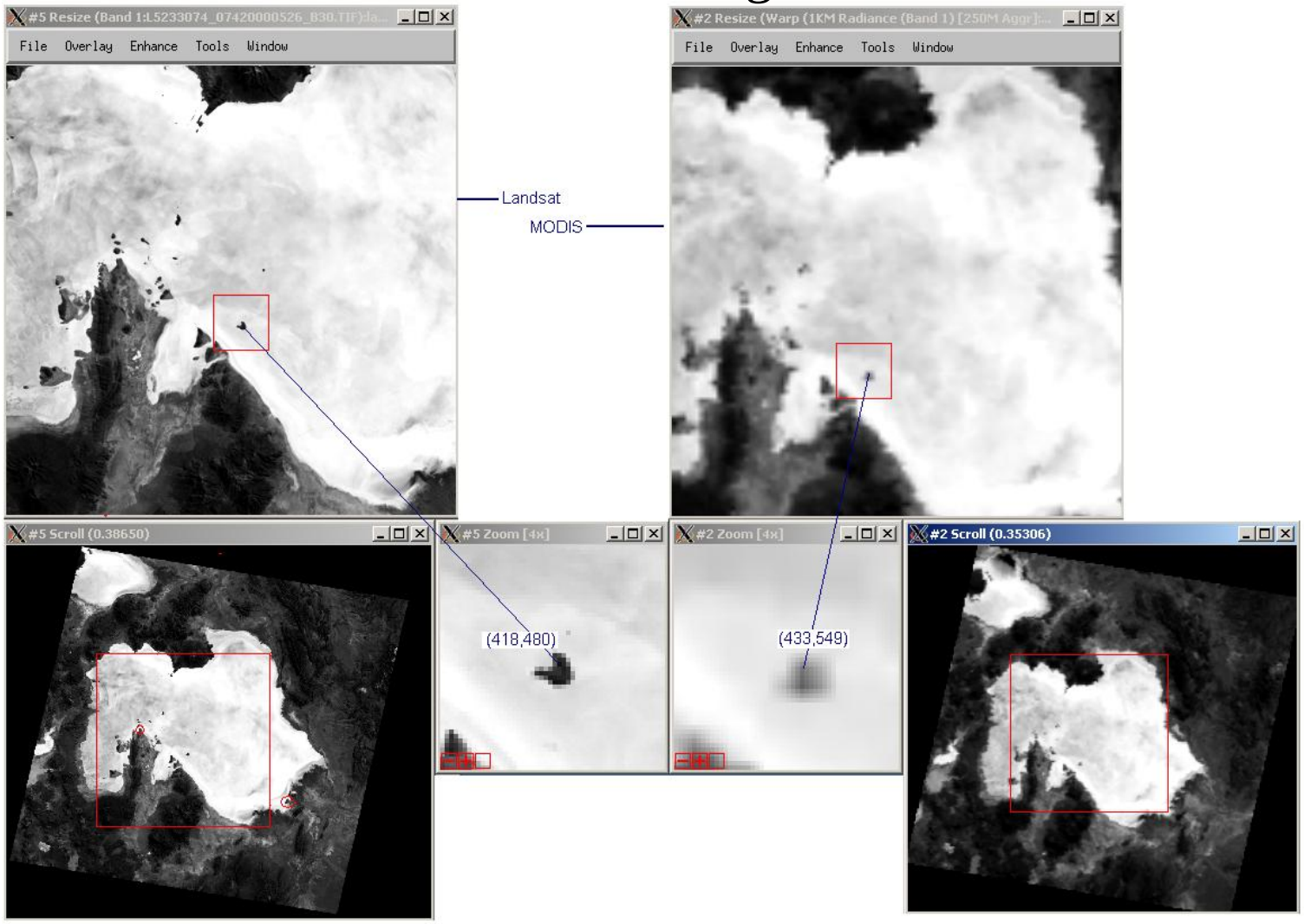
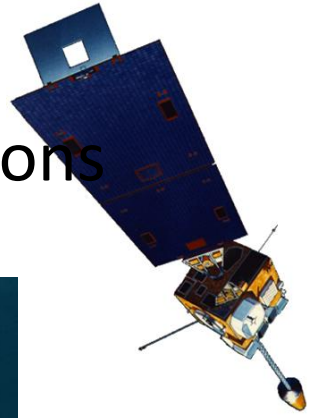
Geolocation Verification using Landsat Data



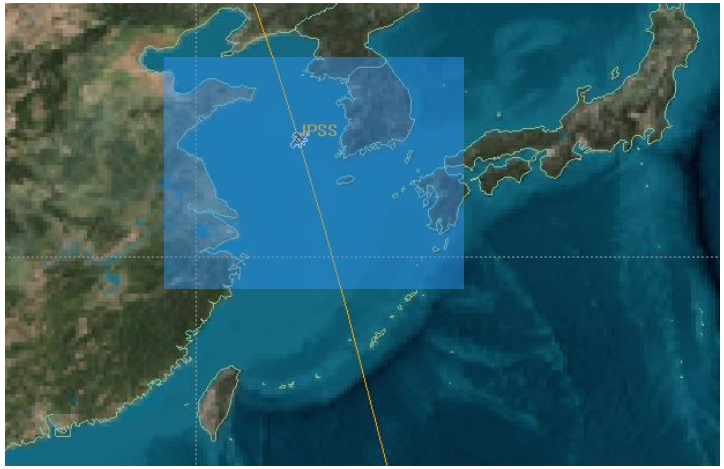
- Landsat and MODIS resampled to 250m in both directions.
- Center pixels for image chip in Landsat and matched pixel in MODIS are shown.

Establishing Consistency for Satellite Observations



- Consistency is critical for interoperability
- Can be established through inter-satellite calibration, and at common standard cal/val sites endorsed by CEOS
- NOAA is leading the WMO/Global Space-based Inter-calibration System (GSICS) for operational satellites
- Long-term goal of establishing SI traceability through rigorous comparisons/inter-comparisons with reduced uncertainties, in partnership with the standards organizations

Example Simultaneous Nadir Overpass between NPP and Aqua for inter-satellite calibration



Transfer calibration to Geostationary satellites

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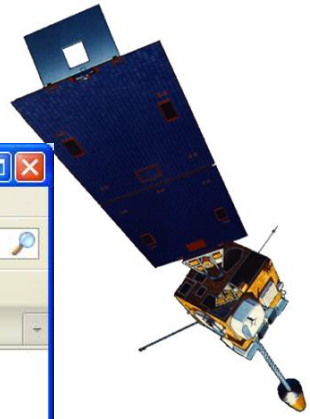

GSICS Global Space-based Inter-Calibration System | Home page - Mozilla Firefox

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http://gsics.wmo.int/

wmo gsics

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GSICS Global Space-based Inter-Cali...

GSICS Global Space-based Inter-Calibration System

An international collaboration to monitor, improve and harmonize data quality from operational environmental satellites for climate monitoring and weather forecasting.

GSICS Portal

Provided by WMO Space Programme

Home | Objectives | Membership | Structure | Contacts | Meeting Reports | GSICS Glossary

GSICS Home

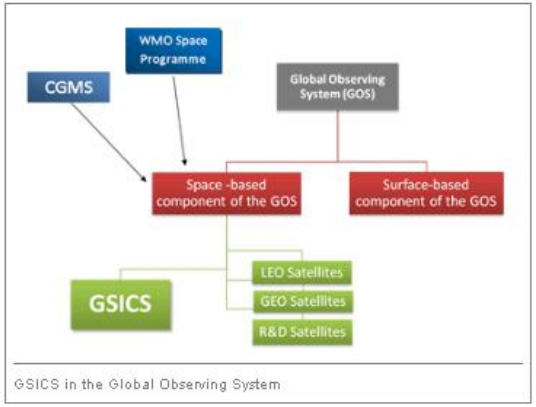
GSICS is an international collaborative effort initiated in 2005 by WMO and the CGMS to monitor and harmonize data quality from operational weather and environmental satellites of the Global Observing System (GOS).

GSICS aims at ensuring consistency among space-based observations worldwide for climate monitoring, weather forecasting, and environmental applications.

This is achieved through a comprehensive calibration strategy involving operational inter-calibration of satellite instruments, tying the measurements to absolute references and standards, and recalibration of archived data.

GSICS delivers calibration corrections needed for accurately integrating data from multiple observing systems into products, applications and services.

GSICS contributes to the integration of satellite data within the Global Earth Observation System of Systems (GEOSS) of the Group on Earth Observations (GEO).



GSICS in the Global Observing System

Product, Services and Technical Information

Central Resources

GSICS Coordination Centre

GSICS WIKI

GSICS Processing and Research Centres (GPRCs)

GPRC NOAA/NESDIS

GPRC CMA/NSMC

GPRC EUMETSAT

GPRC JMA

Other links

NASA/Langley/Calibration

GSICS Global Space-based Inter-Calibration System | 2010

Done

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GSICS organization

CGMS

WWW GOS

Space-based component of GOS

WMO Space Programme

GSICS

GEO satellites

LEO satellites

R&D satellites

GSICS Executive Panel

GRWG

GDWG

CSS

GCC

GPRC

Calibration Support Segments (reference sites, benchmark measurements, aircraft, model simulations)

Coordination Center

Regional Processing Research Centers at Operational Space Agencies

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http://calval.cr.usgs.gov/highlights/gsics-working-group-meeting-in-daejeon-south-korea/

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GSICS Working Group Meeting in Daejeon, South Korea

By admin • Mar 18th, 2011 • Category: Highlights

The Global Space-Based Inter-Calibration System (GSICS) working group will be held in Daejeon, South Korea from March 22 – 25, 2011. GSICS is an international collaborative effort initiated to monitor and harmonize data quality ensuring consistency among space-based observations worldwide for climate monitoring, weather forecasting, and environmental applications. The GSICS Research Working Group (GRWG), is in-charge of inter-calibration methodology and the GSICS Data Working Group (GDWG) and developing operational procedures for data exchange and data management. USGS has recently become a member of GSICS and has a number of Cal/Val activities including cross-calibration between sensors and development of an online catalog of world-wide test sites in support of the GSICS. The discussion and the results from the meeting directly support the USGS EROS Remote Sensing Consultation and Coordination (RSCC) and the Remote Sensing Technologies (RST) Project's. The director of USGS has nominated the staff from RST to represent USGS on the GSICS Executive Panel. (Gregory L. Stensaas, 605-594-2569, stensaas@usgs.gov; Thomas M. Holm, Sioux Falls, SD, 605-594-6127, holm@usgs.gov March 17, 2011).

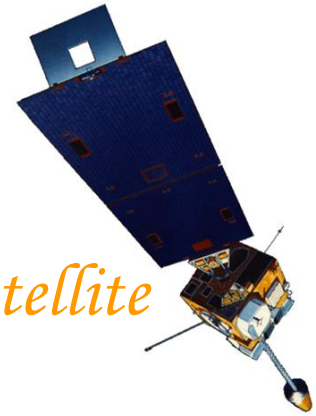
MORE FROM HIGHLIGHTS

- OSL Staff Support Ongoing Research Requests
- GSICS Working Group Meeting in Daejeon, South Korea
- Request for Information for Optical Science Laboratory
- Major Manufacturer of Digital Airborne Sensors at EROS RST
- Partnering to Build a Remote Sensing Radiometry Lab at SDSU
- RFI and Digital Imagery QA Plan Status
- Fees at the USGS Optical Science Lab to Go Up
- USGS participation in High Profile CEOS Publication
- RST Project Provides Technical Advice for International Space Station Effort
- RST Project Engages in Significant Activity Revision
- **Archive for 'Highlights' »**

National Environmental Satellite, Data, and Information Service

GEO-LEO Inter-Comparison Results

… Towards Web-based Near-Real Time GEO-LEO Satellite Inter-comparisons



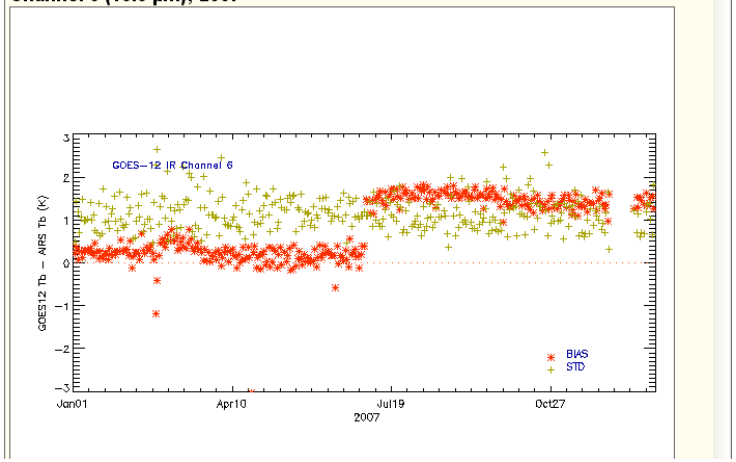
GSICS Home > GEO-LEO Intercalibration > GEO-LEO Intersatellite Instrument Characteristics - GOES-12 Imager vs. Aqua AIRS

GOES-12 Imager vs. Aqua AIRS - To display comparison graphs, please select a month, year, and channel and then click 'Show Tb Biases'.

Tb Biases Within a Month
Month: Select a month
Year: Select a year
Channel: Select a channel
Show Tb Biases

Tb Biases Within a Year
Year: 2007
Channel: Channel 6 (13.3 µm)
Show Tb Biases

GEO-LEO GOES-12 to Aqua AIRS T_b Comparison
Channel 6 (13.3 µm); 2007



MTSAT-1R Infrared Channel
- (•) IR1 (10.8 µm)
- ( ) IR2 (12.0 µm)
- ( ) IR3 (6.8 µm)
- ( ) IR4 (3.8 µm)

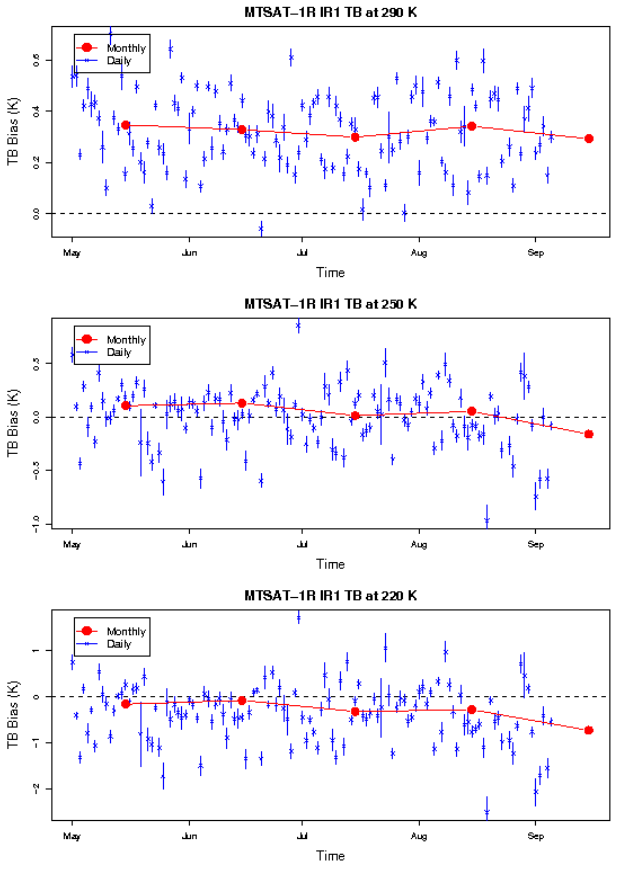
Time Sequence
- (•) TB Difference
- ( ) Sounder Radiance vs. MTSAT-1R Radiance
- ( ) Sounder Radiance vs. MTSAT-1R HRIT Count

Monthly Statistics
- ( ) Scatter Plot

(Month Year)
May 2008
Jun 2008
Jul 2008
Aug 2008
Sep 2008

Push the button
Download CSV
to get a monthly statistics CSV file

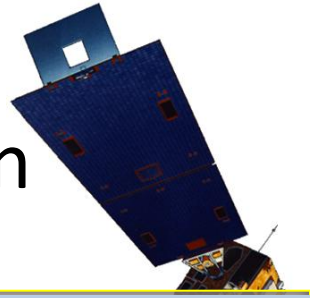
Brightness Temperature Bias (AIRS/IASI – MTSAT-1R IR1)



ABOVE - NOAA/NESDIS On-line results for GOES-12 Channel 6 to EOS Aqua AIRS Comparisons

RIGHT - JMA On-line results for MTSAT 10.8 micron channel compared to AIRS and IASI

The Challenges of Climate Change Detection



- The 30+ years of NOAA satellite observations are valuable assets
- However, climate change detection has stringent requirements
- Using historical weather satellite data from legacy instruments for climate applications requires more rigorous re-calibration and reprocessing
- The newly formed NOAA Climate Service is unifying NOAA's climate capabilities

Climate quality calibration requirements - examples

Albedo: 1% stability

Sea Surface Temperature (SST): 0.1K stability

Ocean Color: 0.1% absolute accuracy

Sea Surface Height: 1 mm per year.

- Global Climate Observing System (GCOS) & ASIC3 report

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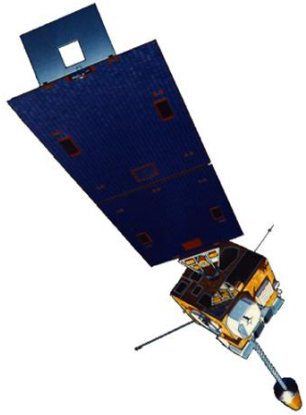

Summary

- Progress with GOES-R cal/val
- NPOESS to JPSS transition
- Re-calibration to generate climate data records
- Welcome USGS joining GSICS